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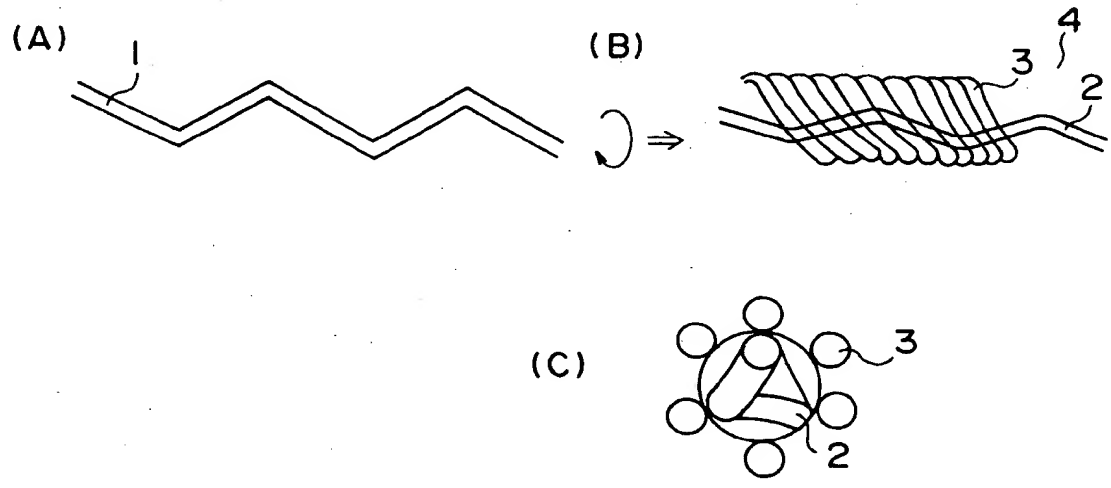
(54) Steel cord for reinforcing rubber articles and pneumatic radial tire using the same.

(57) A steel cord (4) for reinforcing rubber articles and a pneumatic radial tire (10) having a belt layer (14) using the same, in which the steel cord comprises a crimped-curled core (2) made of a steel filament wave-shaped in a plane (crimped) and turned (curled) and 5 - 8 sheath filaments (3) wound around the core in the same direction as the turn direction of the core. The wavelength λc of core-crimp is preferably defined as $8dc \leqq \lambda c \leqq 30dc$ when the diameter of the core filament is dc, and the turn-number nc of the core around the center axis of the core per one wave-length of the core-crimp is preferably defined as $0.12 \leqq nc \leqq 0.85$ (turn/pitch).

Since the core filament is three-dimensional, the core periphery in cross-section is lengthened and the rubber penetration property is remarkably enhanced so that the resistance to cut separation indicating tire durability is enhanced. The space between cords can be lengthened when the strength is constant and the resistance to BES is enhanced. Productivity is better than that of core crimped cord.

FIG. 1



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The present invention relates to a steel cord for reinforcing rubber articles such as pneumatic tires, industrial belts and the like, and more particularly to rubber articles and their steel cord having enhanced rubber penetration property, enhanced resistance to cut separation indicating tire durability, and good resistance to BES (belt edge separation). The invention also particularly relates to pneumatic radial tires using such steel cord.

Products reinforced with steel cords are liable to suffer from corrosion of steel filament caused by water entering the products and thereby the durability and life of the products are lowered.

For example, when steel cords used in a belt of a tire have a void and the tire tread is subjected to damage reaching the belt, water entering the belt spreads along the longitudinal direction of the cord through the voids in the steel cords. As a result, rust formed due to water also diffuses and the adhesion between rubber and steel cord is lowered at that portion. Finally, separation phenomena occur.

In order to prevent such corrosion propagation, there is proposed a cord structure in which rubber can sufficiently penetrate into the inside of the cord through gaps between adjacent metal filaments by pressured vulcanization.

Japanese Patent Application Laid-open Nos. 8208/1985 and 1790/1984 disclose that one of the above-mentioned cord structures, so-called "1+5 structure" cord composed of one core filament and five sheath filaments, has gaps between sheath filaments and rubber can easily penetrate into the gaps, and further this cord can be produced by one-step twisting and thereby the productivity is high.

Indeed the average sheath gaps are sufficient in such a cord structure, but deviation occurs in the arrangement of sheath filaments and there are formed attaching portions of the filaments resulting in forming of portions where rubber does not penetrate due to fluctuation in the manufacturing procedure.

Objects of the present invention are to provide a steel cord having remarkably enhanced rubber penetration property by changing the structure of a core filament and good resistance to BES, and to provide a pneumatic radial tire using the same.

The present inventor has made intensive researches and studies so as to overcome the above-mentioned problems and found that it is possible to enhance the rubber penetration property and the resistance to cut separation and also to enhance the resistance to BES property by using a crimped-curled core made of a core filament wave-shaped in a plane with suitable wavelength and curled with suitable turn number per one wavelength, and as a result the present invention has been accomplished.

The present invention provides a steel cord for reinforcing rubber articles, which comprises a crimp-curled core made of a steel filament wave-shaped in a plane (crimped) and turned (curled) and 5-8 sheath filaments wound around the core in the same direction as the turn direction of the core.

The wavelength λc of core-crimp is preferably defined as $8dc \leqq \lambda c \leqq 30dc$ when the diameter of the core filament is dc, and the turn-number nc of the core around the center axis of the core per one wave-length of the core-crimp is preferably defined as $0.12 \leqq nc \leqq 0.85$ (turn/pitch).

The core filament and the sheath filaments preferably comprise steel thin wire which contain carbon in an amount of 0. 80 - 0.85% by weight.

The invention in another aspect provides a pneumatic radial tire having a belt layer using the steel cord according to the first aspect of the invention.

The invention will be further described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1(A) is a schematic plane section of a core filament wave-shaped in a plane (crimped);

Figure 1(B) is a schematic plane section of a crimped-curled core obtained by making the core filament of Figure 1(A) turned around the center axis of the core (curled) and sheath filaments wound around the core in the same turn direction as the core;

Figure 1(C) is a schematic cross-section of a crimped-curled core steel cord cut along the vertical plane to the turn axis of Figure 1(B);

Figure 2 is a schematic cross section of a pneumatic radial tire indicating the position of a belt using the steel cord according to the present invention;

Figure 3 is a schematic plane section illustrating the definition of the wavelength λc, the amplitude Ac and the core filament diameter dc of the crimped-curled core;

Figure 4 is a schematic cross-section illustrating the definition of the periphery of the cross-section of the crimped-curled core filament and the turn number nc of the core around the center axis of the core per one wavelength of the core crimp;

Figure 5 is an explanatory drawing of definition of the corrosion length x indicating the resistance to cut separation; and

Figure 6 is an explanatory drawing of a belt edge portion showing crack linkage in a test of the resistance to BES.

According to the invention, it is preferable for a pneumatic radial tire 10 having a carcass 12 and a belt 14 (see Fig. 2) to use a steel cord 4 having one crimped-curled core 2 and 5 - 8 sheath filaments 3 and having a core filament diameter dc of 0.15 - 0.48 mm.

A crimped-curled core 2 is wave-shaped in a plane and it is preferable that the amplitude Ac defined in Fig. 3 is within the range described as follows when, for example, 1 + 5 means having one core and five sheath filaments:

1 + 5 $1.12dc \leqq Ac \leqq 2.0dc$ (mm)
1 + 6 $1.12dc \leqq Ac \leqq 2.5dc$ (mm)
1 + 7 $1.42dc \leqq Ac \leqq 2.8dc$ (mm)
1 + 8 $1.74dc \leqq Ac \leqq 3.12dc$ (mm)

When Ac is more than this maximum value, the cord properties become poor to cause, for example, projection of the core 2 from the gap between sheath filaments. When Ac is less than the minimum value, the rubber penetration property is insufficient.

The wavelength λc of the wave crimp of the core 2 (defined in Fig. 3) is defined as $8dc \leqq \lambda c \leqq 30dc$. When λc is less than 8dc, it is not preferable in manufacturing because shaping pitch becomes too short and the core 2 easily breaks.

The turn number nc of the core 2 around the center axis of the core 2 per one wavelength of the core crimp is defined as $0.12 \leqq nc \leqq 0.85$ (turn/pitch). When nc is less than 0.12, it is difficult to form the core 2 into three-dimensional shape. When nc is more than 0.85, the resistance to fatigue due to the twisting of the core 2 is lowered.

The twisting direction of the sheath filaments 3 is the same as the turned direction of the core crimp. This is because, when the respective directions are different, the fretting property including wear-corrosion becomes large by point attachment, and because, when the respective directions are the same, manufacturing is easy.

The number n of the sheath filaments 3 is selected within 5 - 8 and the 1 + 6 structure is preferable. This is because the rubber penetration efficiency is good and the weight can be lowered when strength per unit area of cloth-like composite is constant.

By selecting the carbon content to be from 0.80 - 0.85%, the strength per one cord is enhanced, and the weight can be reduced when its specific strength is constant. Moreover the resistance to BES is enhanced by widening the space between the cords 4 because the cord diameter can be reduced when the cord structure and the strength per one cord are equal.

The rubber penetration property is remarkably enhanced and the resistance to cut separation indicating a kind of tire durability is enhanced by making core filament 1 crimped-curled. The periphery 5 of the cross-section of the core 2 is lengthened (see Fig. 4) and rubber can easily penetrate between sheath filaments 3 because the crimped-curled core 2 is three-dimensional. Further the space between cords 4 is lengthened when the strength is constant and the resistance to BES indicating other kind of durability is enhanced because the maximum cord diameter can be reduced when the core periphery 5 is constant.

The invention will be further described with reference to the following illustrative Examples.

There were prepared tires using the cords described in Table 1, which were then evaluated in respect of resistance to cut separation (average length of corrosion) and resistance to BES (crack linkage percentage), and the results of such evaluation are also given in Table 1.

Table 1

	Prior Example	Comparative Example 1	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Comparative Example 2
Structure	1 + 6	1 + 6	1 + 6	1 + 6	1 + 6	1 + 6	1 + 6	1 + 6	1 + 5	1 + 7	1 + 7
Core Shape	straight	crimped	crimped -curled	crimped -curled	crimped-curled	crimped-curled	crimped-curled	crimped-curled	crimped-curled	crimped-curled	crimped-curled
Filament Diameter (mm)	0.23	0.23	0.26	0.26	0.23	0.23	0.23	0.23	0.24	0.22	0.22
Carbon content percentage	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Ac/dc	1.0	1.62	1.2	1.5	1.2	1.14	2.0	2.0	1.14	2.0	1.42
λc/dc	∞	16.2	8.0	12.0	16.2	16.2	20	30	20	20	31
nc(turn/pitch)	0	0	0.12	0.12	0.33	0.5	0.85	0.85	0.33	0.5	0.90
Twisting Machine*	Bun	Tub	Bun	Bun	Bun	Bun	Tub	Tub	Tub	Tub	Tub
Core periphery (mm)	0.72	0.87	1.05	1.32	1.00	1.16	1.63	1.60	0.99	1.95	1.02
Rubber Penetration Percentage (%)	20	80	95	90	90	90	85	83	90	80	20
Resistance to cut separation (average length of corrosion)	70	20	7	10	15	10	15	17	12	15	0 70
Resistance to BES (crack linkage percentage)	20	40	0	0	5	10	10	10	15	15	70

* Bun: Buncher -machine
Tub: Tubular-machine

Tire size 185R14 LTR (light truck radial)
Mileage 30,000 km
Evaluating method

(1) Resistance to cut separation

The average corrosion length (x in Fig. 5) of a cut portion 6 of the outermost belt of the two after mileage of 30,000 km is measured.

(2) Resistance to BES

The crack linkage ratio of the outermost belt after mileage of 30,000 km is measured. For example, in Fig. 6, cracks 7 and a crack linkage portion 8 are shown.

The crack linkage ratio =

Number of crack linkage portion 8 between cord-cord / Total number of the portions between cord-cord (%).

The smaller the linkage ratio is, the better the result.

Since the core filament of the steel cord is crimped-curled and the wavelength and the turn number of the core around the center axis of the core per one wavelength is appropriately determined, the rubber penetration property is remarkably enhanced and the resistance to cut separation indicating a kind of tire durability is enhanced. Since the core filament is a three-dimensional arrangement, the core periphery in a cross-section is lengthened and rubber can easily penetrate between sheath filaments. The space between cords when the strength is constant is lengthened and the resistance to BES indicating other kind of durability is enhanced because the cord diameter can be reduced even when the core periphery is constant.

Claims

1. A steel cord (4) for reinforcing rubber articles, which comprises a crimped-curled core (2) made of a steel filament wave-shaped in a plane and turned and 5 - 8 sheath filaments (3) wound around the core in the same direction as the turn direction of the core.

2. A steel cord as claimed in claim 1, characterized in that the wavelength λc of core-crimp is defined as $8dc \leqq \lambda c \leqq 30dc$ when the diameter of the core filament is dc, and the turn-number nc of the core around the center axis of the core per one wave-length of the core-crimp is defined as $0.12 \leqq nc \leqq 0.85$ (turn/pitch).

3. A steel cord as claimed in claim 1 or 2, characterized in that the core filament (2) and the sheath filaments (3) are steel thin wire which contain carbon in an amount of 0.80 - 0.85% by weight.

4. A steel cord as claimed in claims 1 to 3, characterized by having a 1 + 6 structure comprising one core filament (2) and six sheath filaments (3), wherein $1.12dc \leqq Ac \leqq 2.5dc$ (mm) where Ac is the amplitude of the core-crimp and dc is the diameter of the core filament.

5. A pneumatic radial tire (10) having a belt layer (14) using the steel cord (4) according to any of claims 1 to 4.

FIG. 1

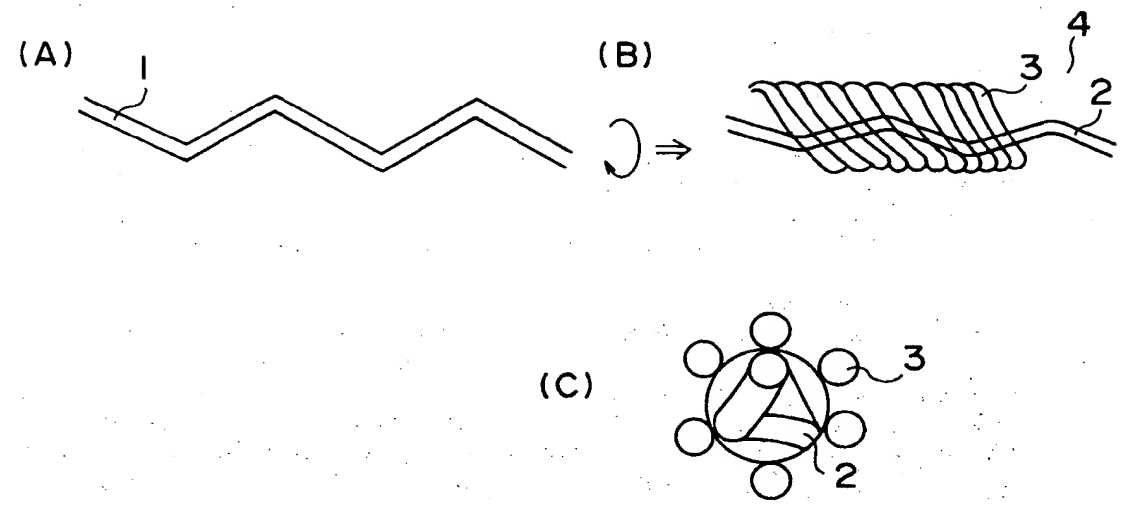


FIG. 2

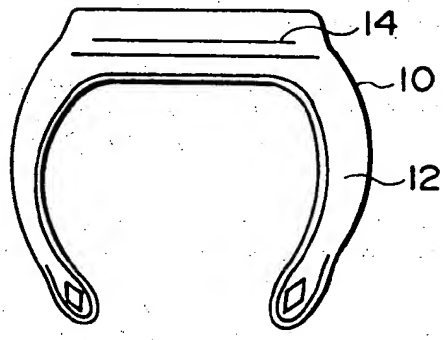


FIG. 3

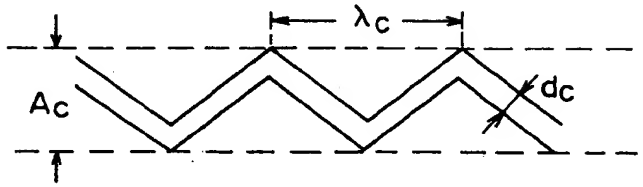


FIG. 4

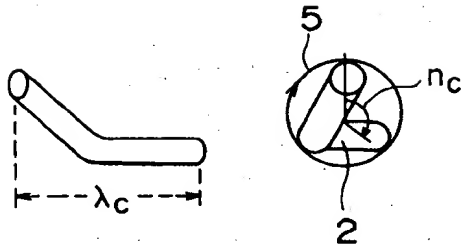


FIG. 5

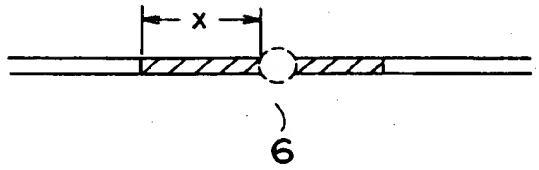
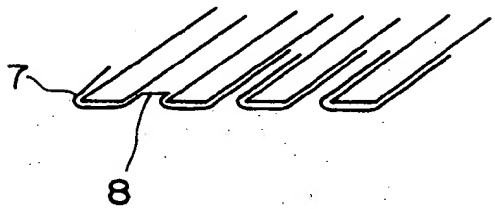


FIG. 6



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EUROPEAN SEARCH REPORT

Application Number
EP 94 30 2088

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	FR-A-2 676 466 (KOKOKU STEEL WIRE LTD.) * page 6, line 10 - line 21 * * page 7, line 24 - line 36 *	1,5	D07B1/06
A	FR-A-2 476 548 (UNIROYAL ENGLEBERT REIFEN GMBH) * page 5, line 6 - line 19 * * page 7, line 15 - line 17 *	1,5	
A	RESEARCH DISCLOSURE, no.175, November 1978, EMSWORTH GB pages 26 - 28 17534 'Process for the manufacture of a strand, as well as a strand made according to this process, and elastomer or synthetic material objects reinforced with such strands' * the whole document *	1,5	
A	EP-A-0 462 716 (TOKUSEN KOGYO COMPANY LTD.) * abstract *	1,5	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)
D07B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14 June 1994	Goodall, C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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